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High lung cancer surgical procedure volume is associated with shorter length of stay and lower risks of readmission and death: national cohort analysis in England.

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ABSTRACT

It is debated whether treating cancer patients in high-volume surgical centres can lead to improvement in outcomes, such as shorter length of hospital stay, decreased frequency and severity of postoperative complications, decreased re-admission, and decreased mortality.

The dataset for this analysis was based on cancer registration and hospital discharge data and comprised information on 15,738 non-small cell lung cancer patients resident and diagnosed in England in 2006-2010 and treated by surgical resection. The number of lung cancer resections was computed for each hospital in each calendar year, and patients were assigned to a hospital volume quintile on the basis of the volume of their hospital.

Hospitals with large lung cancer surgical resection volumes were less restrictive in their selection of patients for surgical management, and provided a higher resection rate to their geographical population. Higher volume hospitals had shorter length of stay and the odds of re-admission were 15% lower in the highest hospital volume quintile compared with the lowest quintile. Mortality risks were 1% after 30 days and 3% after 90 days. Patients from hospitals in the highest volume quintile had about half the odds of death within 30 days than patients from the lowest quintile.

Variations in outcomes were generally small, but in the same direction, with consistently better outcomes in the larger hospitals. This gives support to the ongoing trend towards centralisation of clinical services, but service re-organisation needs to take account of not only the size of hospitals but also referral routes and patient access.

INTRODUCTION

Lung cancer is one of the most frequent types of cancer and the leading cause of cancer death globally.[1, 2] There has been notable progress in lung cancer prevention, as evidenced by declining incidence rates in males,[3] and treatment for lung cancer has become more active and more effective.[4-6] Surgical resection remains the preferred treatment option for medically fit patients with early-stage disease.[7-10]

Lung cancer surgery is highly specialised and increasingly centralised.[5] There is evidence that patient survival is better when surgical care is provided by a multi-disciplinary team in hospitals with high-volume practices, and analysis of surgical data from England in patients diagnosed in 2004-2008 showed lower death rates in patients operated in large-volume hospitals.[11] It remains to be addressed whether treating patients in high-volume surgical centres can lead to improvement in other relevant outcomes, such as shorter length of hospital stay, decreased frequency and severity of postoperative complications, decreased re-admission to hospital, and improved patient experience and satisfaction. The present study extends earlier work on patients undergoing lung cancer surgery in England to examine other outcomes, specifically length of stay in hospital after lung cancer resection, and risks of re-admission and death within 30 and 90 days of surgery.

METHODS

Study population and main predictor variables

The principles of data extraction and linkages were as described previously.[9, 11] The dataset for the analysis comprised information on 15,738 non-small cell lung cancer patients who were resident and diagnosed in England in 2006-2010 and treated by potentially curative surgical resection as part of their initial care. The majority of resections were lobectomy (85%); 10% were pneumonectomy and 5% were other procedures. This is a complete and population-based ascertainment of surgically treated lung cancer in the country. The number of lung cancer resections was computed for each hospital in each calendar year, and patients were assigned to a hospital volume quintile on the basis of the volume of their hospital in the year of diagnosis.

The geographical resection rate was computed as the resected proportion of all non-small cell lung cancer patients in each of 152 geographical primary care trust areas in the period 2006-2010.[9]

Covariates

Sex and age were analysed as categorical variables (age categorised in five-year groups). Socio-economic status was characterised by the quintile of the income domain of the indices of multiple deprivation 2010 on the basis of the residential postcode of each lung cancer patient. Co-morbidity was characterised by a modified Charlson co-morbidity index on the basis of in-patient hospital discharge diagnoses, ignoring the contribution to the co-morbidity index from cancer. Tumour TNM stage and histology were obtained from the National Cancer Registration Service and the National Lung Cancer Audit Dataset (LUCADA).[12] The recorded stage of resected patients is most often the post-operative pathological stage, and may have been further revised in the four months after surgery. Ethnicity was derived from the electronic patient record at hospitals in England in the Hospital Episodes Statistics dataset.

Outcomes

Outcome variables were the length of stay in hospital (in days) at the time of the surgical resection for lung cancer, re-admission as an in-patient to any hospital, regardless of the reason for admission, within 30 and 90 days among the patients who were discharged to their home after the lung cancer resection, and death within 30 and 90 days from the date of surgery.

Statistical analysis

Length of hospital stay distribution was described by the means, and the means of log-transformed values (called the 'log-average' length of stay). Length of stay was analysed in relation to hospital volume quintile and covariates by linear regression of log-transformed length of stay. A two-level linear regression model was fitted with the individual patient as the lower level and a random effect of hospital as the higher level. The risks of re-admission and death were analysed in relation to hospital volume quintile with univariate and multivariate logistic regression analysis. Two-level logistic regression models were fitted with hospital as a random effect. The covariates that were used in adjusted analyses were: geographical resection rate, age, co-morbidity, performance status, stage, histology and ethnicity using categorical variables as described in Table 1.

Table 1. Overview of the study population of 15,738 patients operated for lung cancer in England, 2006-2010. Distributions of variables and cross tabulations of lung cancer surgical procedure volume quintile and the other variables.

					Hospital volume (quintile)									
					1		2		3		4		5	
			N	%	N	%	N	%	N	%	N	%	N	%
Hospital volume Quintile, range	1	1-75	3190	20										
	2	77-112	3230	21										
	3	114-155	3026	19										
	4	156-186	3189	20										
	5	189-287	3103	20										
Geographical resection rate Quintile, range	1	1.6-8.1	1803	11	607	19	363	11	398	13	249	8	186	6
	2	8.2-10.2	2570	16	642	20	557	17	655	22	334	10	382	12
	3	10.2-12.0	3118	20	599	19	678	21	727	24	579	18	535	17
	4	12.0-14.2	3611	23	469	15	822	25	743	25	830	26	747	24
	5	14.2-23.9	4636	29	873	27	810	25	503	17	1197	38	1253	40
					$\chi2(1)=538.2$; $p<0.0001$									
Sex	Male		8572	54	1757	55	1781	55	1600	53	1753	55	1681	54
	Female		7166	46	1433	45	1449	45	1426	47	1436	45	1422	46
					$\chi2(1)=0.5$; $p=0.48$									
Age-group	0-44		1673	11	369	12	346	11	313	10	332	10	313	10
	55-59		1561	10	351	11	333	10	309	10	300	9	268	9
	60-64		2642	17	549	17	535	17	510	17	525	16	523	17
	65-69		3082	20	603	19	593	18	608	20	620	19	658	21
	70-74		3154	20	634	20	653	20	608	20	658	21	601	19
	75-79		2448	16	485	15	520	16	477	16	498	16	468	15
	80-84		1020	6	183	6	209	6	173	6	227	7	228	7
	85+		158	1	16	1	41	1	28	1	29	1	44	1
					$\chi2(1)=14.2$; $p=0.0002$									
Socio-economic status (quintile)	1	Affluent	2383	15	451	14	425	13	479	16	497	16	531	17
	2		2907	18	582	18	631	20	558	18	575	18	561	18
	3		3170	20	669	21	709	22	594	20	593	19	605	19
	4		3468	22	770	24	706	22	669	22	665	21	658	21
	5	Deprived	3810	24	718	23	759	23	726	24	859	27	748	24
					$\chi2(1)=1.1$; $p=0.28$									
Comorbidity index	0		12874	82	2621	82	2655	82	2510	83	2575	81	2513	81
	1		1980	13	397	12	393	12	364	12	417	13	409	13
	2		577	4	126	4	117	4	98	3	123	4	113	4
	3+		307	2	46	1	65	2	54	2	74	2	68	2
					$\chi2(1)=4.1$; $p=0.04$									
Performance status	0		4618	29	885	28	900	28	856	28	946	30	1031	33
	1		3751	24	722	23	685	21	629	21	818	26	897	29
	2		659	4	109	3	91	3	106	4	165	5	188	6
	3		117	1	22	1	19	1	21	1	33	1	22	1
	4		18	0	3	0	3	0	2	0	7	0	3	0
	NA		6575	42	1449	45	1532	47	1412	47	1220	38	962	31
					$\chi2(20)=296.0$; $p<0.0001$									
Clinical stage	1A		2419	15	489	15	493	15	414	14	473	15	550	18

	1B	2793	18	520	16	588	18	536	18	542	17	607	20
	2A	493	3	79	2	101	3	73	2	100	3	140	5
	2B	1390	9	280	9	273	8	263	9	274	9	300	10
	3A	1101	7	189	6	188	6	204	7	246	8	274	9
	3B	476	3	91	3	95	3	89	3	103	3	98	3
	4	417	3	92	3	70	2	63	2	92	3	100	3
	NA	6649	42	1450	45	1422	44	1384	46	1359	43	1034	33
				χ2(28)=179.3; p<0.0001									
Histology	Adeno	8223	52	1652	52	1675	52	1537	51	1747	55	1612	52
	Squamous	5537	35	1092	34	1101	34	1102	36	1138	36	1104	36
	Large cell	341	2	65	2	72	2	104	3	44	1	56	2
	Other spec.	89	1	21	1	21	1	18	1	13	0	16	1
	NSCLC	952	6	231	7	244	8	163	5	136	4	178	6
	NA	596	4	129	4	117	4	102	3	111	3	137	4
				χ2(20)=90.6; p<0.0001									
Ethnicity	White	15196	97	3033	95	3086	96	2947	97	3113	98	3017	97
	Asian	181	1	58	2	46	1	30	1	26	1	21	1
	Black	136	1	38	1	42	1	18	1	16	1	22	1
	Chinese	40	0	11	0	5	0	4	0	12	0	8	0
	Mixed	29	0	11	0	5	0	3	0	3	0	7	0
	Other	92	1	27	1	23	1	11	0	11	0	20	1
	NA	64	0	12	0	23	1	13	0	8	0	8	0
				χ2(24)=80.5; p<0.0001									

RESULTS

Patients

Table 1 gives an overview of the study cohort of 15,738 lung cancer patients diagnosed in the period 2006-2010 in England and treated with surgical resection.

Hospital volume in relation to covariates

Table 1 shows the marginal distributions of the variables in the analysis, and cross-tabulations between the quintile of lung cancer surgical procedure volume (the principal independent variable) and covariates. A high annual hospital volume was strongly associated with a high geographical resection rate ($\chi2=538.2$; $p<0.0001$). There was no association between hospital volume and sex of the patient, but high-volume hospitals had a higher proportion of older patients ($\chi2=14.2$; $p=0.0002$). There was no association with socio-economic status but there were slightly more co-morbid patients in high-volume hospitals ($\chi2=4.1$; $p=0.04$). High-volume hospitals had more complete reporting of performance status and tumour stage than low-volume hospitals, and they used the unspecific histology code “Non-small cell lung cancer (NSCLC)” less frequently. Within the patients with non-missing performance status, the high-volume hospitals had a higher proportion of patients with poor performance status (2 or higher) ($\chi2=14.3$; $p=0.0002$) (Appendix table).

Hospital volume in relation to length of hospital stay

Table 2 shows the length of stay in hospital during the hospitalisation where the lung cancer resection took place. The average length of stay was 9.82 days in the quintile with the lowest hospital volume and 9.35 days in the highest-volume quintile. The linear regression of log-transformed length of stay on hospital volume quintile suggested that the difference in length of stay was about 0.3 days between the extreme quintiles. This gradient was statistically significant with a negative slope ($p=0.004$). Adjustment for the covariates that were associated with resection quintile (geographical resection rate, age, co-morbidity, performance status, stage, histology and ethnicity) made the regression slope marginally steeper, reflecting the more adverse case-mix of patients in high-volume hospitals. A two-level adjusted regression model with the individual hospital as a random effect reduced the statistical significance of the association between hospital volume and length of hospital stay (data not shown).

Table 2. Length of stay (LOS) in the hospital admission with lung cancer resection in relation to quintile of lung cancer surgical procedure. Regression of log-transformed LOS on hospital volume quintile.

	Hospital volume (quintile)					
	All	1	2	3	4	5
LOS mean, days	9.60	9.82	9.88	9.61	9.33	9.35
LOS mean, days, log-average*	8.23	8.26	8.44	8.31	8.02	8.12
LOS mean, days, predicted from regression		8.37	8.30	8.23	8.16	8.09
		Test for trend in log LOS: p=0.004				

*The log-average LOS is exp(mean(log(LOS)))

Hospital volume in relation to re-admission and mortality

Table 3 shows the associations between hospital volume quintile and the risk of re-admission as an in-patient to a hospital and the risk of mortality, each within 30 and 90 days of surgery. Patients operated in high-volume hospitals had lower re-admission risks (19% in quintile 5 vs. 22% in quintile 1 for 30-day readmission, p for trend over the five quintiles: p=0.08; and 44% vs. 47% for 90-day readmission, p<0.0001). Similarly, mortality risk were lower in high-volume hospitals (0.5% vs. 1.0% within 30 days, p=0.01; and 2.2% vs. 3.1% within 90 days, p=0.02).

Table 3. Proportions of the resected lung cancer patients with 30-day and 90-day readmission to hospital, and the proportions who died within 30 days and 90 days. Overall distributions and associations with quintile of lung cancer surgical resection volume.

				Hospital volume quintile									
				1		2		3		4		5	
		N	%	N	%	N	%	N	%	N	%	N	%
Readmission, 30d	N	12487		2477		2581		2392		2550		2487	
	Y	3106	20	680	22	607	19	610	20	610	19	599	19
				χ2(1)=3.1; p=0.08									
Readmission, 90d	N	8440		1642		1654		1653		1780		1711	
	Y	6855	45	1450	47	1465	47	1301	44	1314	42	1325	44
				χ2(1)=15.2; p<0.0001									
Mortality, 30d	N	15593		3157		3188		3002		3160		3086	
	Y	145	0.9	33	1.0	42	1.3	24	0.8	29	0.9	17	0.5
				χ2(1)=6.5; p=0.01									
Mortality, 90d	N	15295		3092		3119		2954		3094		3036	
	Y	443	2.8	98	3.1	111	3.4	72	2.4	95	3.0	67	2.2
				χ2(1)=6.0; p=0.02									

Table 4 shows the more detailed analyses of 30-day and 90-day readmission risks in relation to hospital volume quintile. Statistical adjustment for geographical resection rate, age, co-morbidity, performance status, stage, histology and ethnicity strengthened the associations between hospital volume and 30-day and 90-day readmission risks. Further allowance for the two-level structure of the data by fitting a random effect of individual hospital further strengthened the association with 30-day re-admission risk, but the association with 90-day readmission was much attenuated in the two-level model.

Table 4. Univariate and adjusted analyses of 30-day and 90-day risks of readmission to hospital, in relation to lung cancer surgical procedure volume quintile.

			Readmission in 30 days									Readmission in 90 days								
			%	OR¹	95% CI		OR²	95% CI		OR³	95% CI	%	OR¹	95% CI		OR²	95% CI		OR³	95% CI
Hospital	1	1-75	22	1.00			1.00			1.00		47	1.00			1.00			1.00	
volume	2	77-112	19	0.86	0.76	- 0.97	0.85	0.75	- 0.96	0.86	0.75 - 0.99	47	1.00	0.91	- 1.11	1.01	0.91	- 1.12	0.90	0.79 - 1.02
(quintile)	3	114-155	20	0.93	0.82	- 1.05	0.92	0.81	- 1.04	0.90	0.77 - 1.04	44	0.89	0.81	- 0.99	0.88	0.79	- 0.97	0.85	0.73 - 0.98
(range)	4	156-186	19	0.87	0.77	- 0.98	0.85	0.75	- 0.96	0.85	0.73 - 0.99	42	0.84	0.76	- 0.92	0.82	0.74	- 0.90	0.88	0.76 - 1.03
	5	189-287	19	0.88	0.78	- 0.99	0.85	0.75	- 0.96	0.82	0.69 - 0.97	44	0.88	0.79	- 0.97	0.84	0.76	- 0.94	0.93	0.78 - 1.10
Trend				*χ^2=3.1, p=0.08*			*χ^2=5.2, p=0.02*			*χ^2=4.6, p=0.03*			*χ^2=15.2, p<0.0001*			*χ^2=21.9, p<0.0001*			*χ^2=0.7, p=0.40*	

OR¹: Crude odds ratio.

OR²: Adjusted for geographical resection rate, age, co-morbidity, performance status, stage, histology and ethnicity.

OR³: Adjusted as OR², and also allowing for variation in readmission between individual hospitals.

Table 5 shows the detailed analyses of 30-day and 90-day mortality outcomes. For both endpoints, higher hospital volume was associated with lower risks of death, and this did not change much with adjustment for covariates or with the allowance for variation between hospitals.

Table 5. Univariate and adjusted analyses of 30-day and 90-day mortality risks, in relation to lung cancer surgical procedure volume quintile.

			Mortality in 30 days							Mortality in 90 days						
			%	OR[1]	95% CI	OR[2]	95% CI	OR[3]	95% CI	%	OR[1]	95% CI	OR[2]	95% CI	OR[3]	95% CI
Hospital	1	1-75	1.0	1.00		1.00		1.00		3.1	1.00		1.00		1.00	
volume	2	77-112	1.3	1.26	0.80 - 1.99	1.23	0.77 - 1.96	1.26	0.75 - 2.11	3.4	1.12	0.85 - 1.48	1.12	0.85 - 1.49	1.15	0.85 - 1.56
(quintile)	3	114-155	0.8	0.76	0.45 - 1.30	0.75	0.44 - 1.28	0.77	0.43 - 1.38	2.4	0.77	0.56 - 1.05	0.78	0.57 - 1.07	0.79	0.56 - 1.11
(range)	4	156-186	0.9	0.88	0.53 - 1.44	0.87	0.52 - 1.46	0.84	0.47 - 1.50	3.0	0.97	0.73 - 1.29	0.94	0.70 - 1.26	0.95	0.68 - 1.31
	5	189-287	0.5	0.53	0.29 - 0.95	0.52	0.29 - 0.95	0.50	0.25 - 1.01	2.2	0.70	0.51 - 0.95	0.66	0.48 - 0.91	0.67	0.46 - 0.96
Trend				*χ^2=6.5, p=0.01*		*χ^2=6.2, p=0.01*		*χ^2=4.3, p=0.04*			*χ^2=6.0, p=0.02*		*χ^2=7.8, p=0.005*		*χ^2=4.8, p=0.03*	

OR[1]: Crude odds ratio.

OR[2]: Adjusted for geographical resection rate, age, co-morbidity, performance status, stage, histology and ethnicity.

OR[3]: Adjusted as OR[2], and also allowing for variation in mortality between individual hospitals.

DISCUSSION

Interpretation of the results of adjusted analyses and two-level analyses

The principal findings of these analyses are:

1: Hospitals with large lung cancer surgical resection volumes are less conservative in their selection of patients for surgical management, and they provide a higher resection rate to their geographical population.

2: With adjustment for case-mix, high-volume hospitals have shorter length of stay, with approximately 0.3 days difference between the extreme quintiles of hospital volume. The error of this estimate is large, however, particularly when the two-level structure of the data is considered.

3: Re-admission risks are high after lung cancer resection (20% and 45% are readmitted as in-patients to hospital within 30 and 90 days, respectively). The odds of re-admission are about 15% lower in the highest hospital volume quintile compared with the lowest quintile. The estimated 30-day re-admission risk is not influenced by clustering of this outcome within individual hospitals, but the variation in 90-day readmission risk has a large contribution from the level of the individual hospital.

4: Overall mortality risks after lung cancer resection are 1% after 30 days and 3% after 90 days. Patients from hospitals in the highest volume quintile have about half the odds of death within 30 days than patients from the lowest quintile. For 90-day mortality the corresponding odds ratio is 0.7.

The results suggest that there are systematic differences between smaller and larger hospitals that facilitate better patient outcomes in the larger hospitals, despite their more inclusive criteria for selection and the resulting adverse case-mix. In addition, it seems that the culture of data collection is better in the larger hospitals where completeness of recording of stage and performance status is highest. Other variations, not currently captured in the cancer register, may be availability of staging methods (e.g. endoscopic ultrasound and PET scanning) and the systematic use of adjuvant chemotherapy.

Comparison with other studies

The analyses of 30-day and 90-day mortality risks in relation to hospital volume are consistent with previous analyses of hazard ratios for death.[11] The analyses of mortality outcomes in lung cancer patients in England in relation to surgical procedure volume adds to the growing body of evidence of favourable outcomes in high-volume hospital settings.[11, 13-16] It is noteworthy that the 30-day mortality outcome is insufficient to capture the full mortality effect, and that 90-day mortality is more than three times the magnitude of 30-day mortality (2.8% vs. 0.9%). Similar findings were reported in a large study in the USA.[17] This emphasises that mortality outcomes should be considered both in the short and the longer term.[11]

The results for length of stay and re-admission emphasise that these outcomes vary along the gradient from low hospital volume (and high mortality) to high volume (and lower mortality). Recent studies have explored associations within the wider set of outcomes: hospital volume, length of stay, complications, re-admission, mortality, and cost.[17-30] The emerging pattern is one of correlated and consistently favourable outcomes in high-volume hospitals. We are not aware of any studies of patient-reported outcomes and patient experience in relation to hospital volume, which should be an area for further research.

Threshold of effects?

It has been considered whether the associations with hospital volume would be characterised by a threshold above which increasing hospital volume would not provide any further increase in clinical benefit.[31] The present analysis was not designed to establish a threshold value. We consider that such analysis should pre-specify the hypothetical threshold value, and then proceed similarly to a formal equivalence trial.[32] Regardless, the present data suggests that there may well be different thresholds (if any) for different outcomes. Length of hospital stay and re-admission risks are numerically similar in quintiles 4 and 5 (i.e. above a possible threshold around 150 procedures per year), but in the analysis of mortality risks the data would suggest continued increase in benefit above around 190 procedures per year.

The structure of health care systems and models of care vary between countries, and it is not necessarily the case that associations with procedure volume would be similar between countries or that any thresholds would be the same. For example, the large study of lung cancer resection in the USA[17] considered 90 procedures per year as the cut-off point for their high-volume group of patients, but this falls within the second quintile in the present data and would be considered as a low volume in England.

Strengths and limitations

The present analysis benefit from systematically collected data with uniform standards and classifications in a large national population. The quality and completeness of cancer registration data in England have improved in recent years, and tumour stage is now available in the majority of cases. Ascertainment of outcomes is based on routinely collected data and unlikely to differ artifactually between hospitals with different practice volume. However, the use of routinely collected data is also the main limitation of the study, and information on co-morbidity, performance status and histology are subject to a higher degree of error than we would expect from a smaller study based on more fully quality-assured clinical data.

The 30 and 90-day re-admission rates are remarkably high regardless of which type of hospital treated the patients. The data does not define why the patients were re-admitted, which may be for reasons other than for management of post-operative complications.

We note that a high number of hospitals contribute to this data set. The record linkages identified the combination of lung cancer registration and a relevant surgical resection in patients with resection reported from 78 hospitals, but these resections should mainly or entirely take place in the 30 thoracic centres in England.[6] The data set includes a number of hospitals that contributed only a single or a few records to the data set. We have no means of quality assuring these records which for a large part may be due to errors of coding and registration. These hospitals with very few resections are all in quintile 1 of the hospital procedure volume grouping, and make up a small proportion of the 3190 patients in this group. We can judge the magnitude and direction of possible bias from the inclusion of these records by looking at associations across quintiles 2-4. Such restriction strengthens the association with length of stay (Table 2) and with mortality (Table 5), and it has little or no impact on the analysis of readmission risks (Table 4).

These findings support the view that the principal problem is too few lung cancer patients gaining access to a thoracic surgical service. The ultimate validation of this conjecture may require the collection of more detailed information on patient preferences, local clinical policies and decision making processes than are available in the routine cancer registration system.

Are the observed differences clinically relevant?

We have described differences in bed-days, readmissions and deaths in terms of a relative measure (the odds ratio), Chi-square measures of association, and associated p-values. These standard measures allow for testing of the *a priori* hypotheses of association, but tells us little about the clinical and practical relevance of the observed variations in outcomes. In order to address this we computed (from the data in Tables 2 and 3) the total counts of bed-days, readmissions and deaths, and the number and proportion of these that would have been avoided if the patients in hospital volume quintiles 1-4 had experienced the same (lower) bed-days and risks as the patients in quintile 5.

In absolute terms, the strongest signal in these data is found for 30-day post-operative mortality. Of the 145 deaths that were observed, 65 deaths (45%) would have been avoided if the 12,635 patients in quintiles 1-4 had experienced the low 0.5% mortality risk of the 3103 patients in quintile 5.

Similar calculations show that 24% of the 90-day post-operative deaths are attributable to the variation in 90-day mortality between the quintiles, but for bed-days and readmissions, the proportions so attributable are only a few percent and each of these variations are not of practical relevance. It remains important that all the variations are in the same direction, with consistent better outcomes in high-volume hospitals.

Crawford et al[33] looked at the socio-economic status of patients and the distance they lived both from the diagnostic and the surgical centre. Patients who lived far from the surgical centre had lower rate of surgery than those who lived closer to the centre. Likewise, Khakwani et al[6] showed that surgical centres with large catchment areas resected a high proportion of patients referred directly to the centre, but a smaller proportion of the patients referred to them from other hospitals. So, service re-organisation needs to take account of not only the size of hospitals but also referral routes and patient access.[34]

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